

Management of neglected lateral condyle fractures of humerus in children: A retrospective study

Anil Agarwal, Nadeem Akhtar Qureshi, Neeraj Gupta, Indreshwar Verma, Devreshi Kumar Pandey

ABSTRACT

Background: Late presentation of humeral lateral condylar fracture in children is a surgical dilemma. Osteosynthesis of the fracture fragment or correction of elbow deformity with osteotomies and ulnar nerve transposition or sometimes both procedures combined is a controversial topic. We retrospectively evaluated open reduction and fixation cases in late presentation of lateral humeral condyle fracture in pediatric cases with regards to union and functional results.

Materials and Methods: Twenty two pediatric (≤ 12 years) patients with fractures of lateral condyle presenting 4 weeks or more post injury between the study period of 2006 and 2010 were included. Multiple K-wires / with or without screws along with bone grafting were used. At final evaluation, union (radiologically) and elbow function (Liverpool Elbow Score, LES) was assessed.

Results: There were 19 boys and 3 girls. Followup averaged 33 months. Pain ($n=9$), swelling ($n=6$), restriction of elbow motion ($n=6$), prominence of lateral condylar region ($n=4$), valgus deformity ($n=4$) were the main presenting symptoms. Ulnar nerve function was normal in all patients. There were nine Milch type I and 13 type II fractures. Union occurred in 20 cases. One case had malunion and in another case there was resorption of condyle following postoperative infection and avascular necrosis. Prominent lateral condyles ($4/12$), fish tail appearance ($n=7$), premature epiphyseal closure ($n=2$) were other observations. LES averaged 8.12 (range, 6.66-9.54) at final followup.

Conclusions: There is high rate of union and satisfactory elbow function in late presenting lateral condyle fractures in children following osteosynthesis attempt. Our study showed poor correlation between patient's age, duration of late presentation or Milch type I or II and final elbow function as determined by LES.

Key words: Late presentation, lateral humeral condyle, nonunion

INTRODUCTION

Lateral condyle fractures of the humerus are one of the commonest fracture occurring at the age of 5-10 years.¹ This fracture is a subject of debate as regards to surgical approach, choice of implants, period of immobilization and management of late presenting/neglected cases.²⁻⁷ In late presentations, the dilemma varies between osteosynthesis of the fracture fragment or correction of elbow deformity with osteotomies and ulnar nerve transposition or sometimes both procedures combined.^{4,6,8-10}

In children, there is risk of having valgus deformity developing as the child grows older and it is argued that osteosynthesis should be attempted early to prevent deformity and enable the condyle to participate in lower humeral growth.^{5,6} We retrospectively evaluated the functional results of osteosynthesis in late presentation of lateral humeral condyle fracture (>4 weeks).

MATERIALS AND METHODS

This retrospective study included 22 patients of late presenting lateral humeral condylar fractures between December 2006 and November 2010. Cases presented 4 weeks or more after initial trauma, were considered as late presentation. These late presenting cases were managed with open reduction and internal fixation. An explained written consent for surgery was obtained from all patients. We used Kocher incision for surgical procedures in all except two where Bryan and Morrey extensile approach to elbow was used in high riding condylar fragment (cases no. 4 and 16).¹¹ We nibbled the humeral metaphyseal area to create space for easy realignment/ rotation of the fragment over the posterior soft tissue pedicle, compensating for

Department of Orthopaedics, CNBC, Delhi, India

Address for correspondence: Dr. Anil Agarwal,
4 / 103, East End Apartments, Mayur Vihar Ph-I Extension, Delhi, India.
E-mail: rachna_anila@yahoo.co.in

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its overgrowth and for procuring bone graft. Sometimes because of overgrowth of condylar fragment it was difficult to distinguish between the articular and the metaphyseal region of the fragment. Under such circumstances, gentle search for overhang of cartilage always helped in locating the metaphyseal area. The excess overlapping cartilage was then trimmed to get bleeding metaphyseal bone. Two to three multidirectional Kirschner wires were used for fixation following reduction. Four millimeter partially threaded AO screws were used in two cases along with Kirschner wires because of available large metaphyseal fragment. Bone graft obtained from metaphyseal fragment of the lateral lower humeral metaphyseal area or proximal ulna was always added during the osteosynthesis. In cases where exact anatomical reduction of the lateral humeral condyle was not possible, most acceptable reduction was fixed. The wires were retained for minimum of 6 weeks and the limb protected in above elbow Plaster of Paris cast up to fracture union. Union was assessed clinicoradiologically at 2 months and thereafter at 1-month intervals. Elbow mobilization was initiated as soon as there was radiological evidence of union.

The results were evaluated by two main parameters: whether union of the lateral condylar fragment was achieved and what was the final function of elbow. The functional results were scored according to Liverpool Elbow Score (LES) incorporating deformity, instability, motion, strength and ulnar nerve assessment.¹² The patients were

assigned scores 0-10, with higher scores indicating better elbow function. Correlation between LES and parameters (patient's age, delay in presentation and Milch type) was determined using Wilcoxon sign test.

RESULTS

The mean age of the patient at the time of presentation was 7 years (range, 3-12 years) [Table 1]. Nineteen were boys and there were only 3 girls. The left elbow was affected in 15 patients. The average delay in presentation was 16 weeks (range, 4-52 weeks). In 13 patients (59%), the delay was more than 12 weeks. Two patients were our own followup where conservative treatment was done initially, but fracture displacement became obvious in followup radiographs and operative intervention was deemed necessary. Eight patients had been to osteopaths prior to reporting at our center. Six patients had taken treatment in form of above elbow Plaster of Paris slab elsewhere initially but never followed up subsequently [Figure 1]. The patient symptomatology and elbow range of motion were recorded as in Table 2. Recording of elbow motion was not possible in 7 patients because of pain and subsequent noncooperation. Due to presence of elbow flexion deformity in several patients, assessment of preoperative cubitus valgus / varus accurately was not possible. Pain 40% ($n = 9$), swelling 27.27% ($n = 6$), restriction of elbow motion 27.27%

Table 1: Clinical details of patients

Age (years)	Sex	Side	Delay in presentation (weeks)	Presenting complaint	Preoperative elbow flexion	Milch type*
7	M	R	8	Pain, swelling	-	II
6	F	L	4	Followup treatment	-	II
8	M	L	16	Decreased elbow motion	10°-50°	II
10	M	L	40	Valgus deformity	10°-90°	II
4	M	R	16	Pain, decreased elbow motion	10°-45°	I
12	M	L	12	Persistent swelling	25°-90°	I
7	F	R	6	Pain, swelling	-	II
7	M	R	6	Pain, swelling	-	I
3	M	L	16	Restriction of elbow flexion	30°-90°	II
8	M	L	8	Lateral prominence at elbow, restriction of elbow flexion	0°-60°	II
8	M	L	20	Lateral prominence at elbow	-20°-135°	II
9	M	L	12	Pain	10°-120°	I
7	F	L	8	Followup treatment	Fixed 90°	I
5	M	L	24	Restriction of elbow extension	40°-120°	II
6	M	L	20	Valgus deformity	10°-130°	II
7	M	L	52	Valgus deformity, Lateral prominence at elbow	10°-130°	II
6	M	L	6	Pain, swelling	-	I
12	M	L	24	Lack of full elbow extension	25°-110°	II
8	M	L	16	Lateral prominence at elbow	10°-135°	II
6	M	R	6	Pain	-	I
6	M	R	4	Pain, swelling	-	I
4	M	R	28	Pain, valgus deformity	0°-130°	I

Abbreviations: M = male, F = female, R = right, L = left. *in some cases, intraoperative trochlear assessment aided in Milch's classification

($n = 6$), prominence of lateral condylar region 18.18% ($n = 4$), valgus deformity 18.18% ($n = 4$) were the main presenting symptoms. Examination for preoperative ulnar nerve function was normal in all patients. There were 9 Milch type I and 13 type II fractures. The fracture fragment was displaced (>2 mm) in 20 patients [Table 3] based on plain anteroposterior radiograph findings.

The overgrowth of condylar fragment and lower humeral lateral metaphyseal area was always an observation during operative reduction in late presenting cases (>6 weeks). Other observations with late presenting cases were mismatch of articular margins of trochlear part and medial end of fractured lateral condylar fragment 54.54% ($n = 12$) and associated articular cartilage damage of fractured lateral condylar fragment in some cases 18.18% ($n = 4$).

The followup averaged 33 months (range, 12-54 months).

Osteosynthesis was achieved in all cases except case no. 3 (malunion) and case no.22 (infection, avascular necrosis and resorbed). The average time to fracture union was 2.8 months. The average LES in the series was 8.12 (range, 6.66-9.54). With delayed presentations, exact anatomical reductions of the lateral condylar fragment were difficult to achieve, but conspicuous alteration in carrying angle was not present except in case no. 3 and 22 [Table 2]. Fish-tail appearance was seen in 31.8% ($n = 7$) cases [Figure 2]. Premature closure of lateral condylar epiphysis was noted in 4 cases (Cases 8, 9, 18, 19) [Figure 2]. The corresponding elbow scores in these patients are given in Table 3.

Comparison of elbow range of motion was not possible in followup because preoperative elbow range of motion was not recordable in 7 patients. Six patients showed loss of extension following osteosynthesis (cases 4, 6, 10, 15, 16, 19), average loss being 15° (range, 5° - 30°). Loss of total elbow range of motion was seen in 7 patients' average being

Table 2: Elbow evaluation according to Liverpool elbow score at final followup

Position of lateral condyle	Management	Outcome	Followup duration in months	Elbow score
Displaced	ORIF 2K wires+BG	Union; Flexion 5° - 120° ; Forearm rotation arch 180°	50	9.10
Displaced	ORIF 2K wires+BG	Union; Flexion 15° - 105° ; Forearm rotation arch 180°	12	8.55
Displaced	ORIF 2K wires+BG	Malunion*; Prominent lateral condyle; Fish tail appearance; Flexion 10° - 90° ; Forearm rotation arch 135°	50	8
Minimal displacement*	ORIF 1K wire+screw+BG	Union; Flexion 30° - 130° ; Forearm rotation arch 180°	40	8
Displaced	ORIF 2K wires+BG	Union; Flexion 5° - 120° ; Forearm rotation arch 150°	47	9.10
Displaced	ORIF 3K wires+BG	Union; Fish tail appearance; Flexion 30° - 70° ; Forearm rotation arch 180°	15	7.6
Displaced	ORIF 2K wires+BG	Union; Flexion 80° - 120° ; Forearm rotation arch 180°	29	7.21
Displaced	ORIF 2K wires+BG	Union; Prominent lateral condyle; Fish tail appearance; Premature epiphyseal closure. Flexion 0° - 135° ; Forearm rotation arch 180°	42	9.54
Displaced	ORIF 2K wires+BG	Union; Fish tail appearance; Premature epiphyseal closure; Flexion 0° - 135° ; Forearm rotation arch 180°	53	9.54
Displaced	ORIF 2K wires+BG	Union; Prominent lateral condyle; Flexion 10° - 120° ; Forearm rotation arch 180°	42	8.22
Minimal displacement	ORIF 3K wires+BG	Union; Fish tail appearance; Flexion 20° - 135° ; Forearm rotation arch 180°	26	9.54
Displaced	ORIF 2K wires+BG	Union; Flexion 10° - 110° ; Forearm rotation arch 180°	24	9.10
Displaced	ORIF 2K wires+BG	Union; Flexion 45° - 105° ; Forearm rotation arch 180°	18	6.55
Displaced	ORIF 3K wires+BG	Union; Flexion 20° - 90° ; Forearm rotation arch 180°	32	6.77
Displaced	ORIF 1K wire+screw+BG	Union; Flexion 40° - 110° ; Forearm rotation arch 180°	13	6.88
Displaced	ORIF 1K wire+BG (fibula)	Union; Flexion 20° - 120° ; Forearm rotation arch 180°	13	8
Displaced	ORIF 3K wires+BG	Union; Prominent lateral condyle; Flexion 20° - 90° ; Forearm rotation arch 150°	18	7.77
Displaced	ORIF 3K wires+BG	Union; Fish tail appearance; Premature epiphyseal closure; Flexion 5° - 110° ; Forearm rotation arch 180°	28	8.22
Displaced	ORIF 2K wires+BG	Union; Fish tail appearance; Premature epiphyseal closure; Flexion 25° - 135° ; Forearm rotation arch 180°	54	8.1
Displaced	ORIF 3K wires+BG	Union; Flexion 5° - 90° ; Forearm rotation arch 180°	16	6.66
Displaced	ORIF 2K wires+BG	Union; Flexion 0° - 135° ; Forearm rotation arch 180°	54	9.54
Displaced	ORIF 3K wires+BG	Got infected; Lateral condyle resorbed; posterior subluxation radial head; cubitus varus; Flexion 0° - 120° ; Forearm rotation arch 150°	51	6.66

Abbreviations: ORIF = open reduction and internal fixation, K = Kirschner, BG = Bone graft. *minimal displacement: displaced less than 2 mm. *malunion: poor anatomical position of lateral condyle causing conspicuous alteration in carrying angle.⁹



Figure 1: X-ray anteroposterior and lateral views of a eight year child presented with prominence in lateral condylar region showing (a) distinct nonunion of lateral condylar fragment (b) followup 26 months later showing sound fracture union (c) Clinical photograph showing elbow range of motion



Figure 2: (a) X-ray anteroposterior and lateral views of a seven year old boy with 6-week-old fracture lateral condyle. The fragment was fixed with multiple Kirschner wires and bone grafted. Sound union was obvious in followup radiographs. (b) Clinical photograph showing range of motion. The prominence of lateral condylar region was probably because of copious bone grafting

Table 3: Correlation of various observations and LES (Liverpool elbow score)

Parameter	No. of cases	LES (Average)	Significance*
Patient age 6-12 years	18	8.14	Not significant
Patient age <6 years	4	8.01	($P=0.59$)
Delay in presentation ≥ 12 weeks	13	8.11	Not significant
Delay in presentation <12 weeks	9	8.12	($P=1$)
Milch type I	9	8.05	Not significant
Milch type II	13	8.16	($P=0.63$)
Fish tail appearance	7	8.64	-
Premature closure of lateral condylar epiphysis	4	8.85	-
Infection	1	6.66	-

*Wilcoxon sign test

20°s (range, 10°-50°). Only in two patients, case 6 and case 15, the loss was significant ($>25^\circ$). In other patients, there was either no change or improvement in elbow range of motion. Development of prominence in lateral condylar

region attributable to new bone formation along Kirschner wires and bone grafting was seen in 3 patients (case 3, 8 and 17). Although causing cosmetic disfigurement, the prominence was no hindrance to elbow function [Figure 2]. One patient developed early postoperative infection (Case 22). The lateral condyle got resorbed following avascular necrosis and posterior subluxation of radial head was noted in follow up radiographs. His elbow function score at final follow up was 6.66. None of our other patients showed development of avascular necrosis of lateral condyle or worsening valgus deformity during the followup.

Our study showed poor correlation between patient's age, duration of late presentation, Milch type and final elbow function achieved (LES values) [Table 4]. However, infection was a significant factor resulting in low LES. Rate of union was 20/22.

Table 4: Comparison of different methods of treatment in late presenting lateral condyle fractures of humerus in children^{10,19-21}

Treatment method*	Nonoperative treatment	Osteosynthesis with reduction of fragment	Corrective osteotomy with/without osteosynthesis
Advantages	May have acceptable range of motion May not have pain May not have cosmetic deformity May not have functional disability	Improvement in elbow stability Less elbow pain during heavy work Prevention of cubitus valgus deformity Prevention of tardy ulnar palsy Normal elbow contour with growth	Corrects cubitus valgus deformity May provide pain relief May improve elbow instability
Limitations	May have pain May have Instability May have progressive cubitus valgus deformity May have late ulnar nerve neuropathy	Loss of motion Osteonecrosis of fragment Persistent nonunion Bone grafting frequently needed Technically Demanding Infection	Loss of correction if performed without osteosynthesis Concomitant ulnar nerve transposition may be required Substantial rotation of lateral condylar fragment makes procedure difficult Loss of range of motion in some cases Infection

*Other alternatives such as *in situ* fixation, isolated ulnar nerve transposition etc. are also described.

DISCUSSION

In developing countries, health care services are not widespread or sometimes the available medical services do not have radiology or operation facilities. Under such circumstances, these fractures are managed by osteopaths as “soft tissue injuries” or even inappropriately at primary centers by conservative means.^{13,14} More sophisticated investigations such as special radiological views, high-resolution ultrasonography and MRI have been suggested to better delineate the fracture.^{8,15-18} In our series, at least 8 patients agreed to have visited osteopath for primary treatment and 6 patients ignored their trauma after initial care and did not consider revisiting a medical center.

Observers have variedly defined the ‘delayed’, ‘neglected’ or ‘late presentation’ lateral condylar fractures (>3-6 weeks) in children.^{4,19,20} We have defined late presentation as >4 weeks post injury in our series. A neglected fracture usually presents with a distorted anatomy. The fractured fragment may be completely displaced with the articular surface of the fragment facing the humeral metaphyseal area or laterally. Despite fracture, the fragment retains its blood supply and continues to grow. Its size enlarges making it difficult to fit in original bony bed, losses its shape to become irregular and becomes so much surrounded on all sides by cartilage that in some late cases it becomes impossible to distinguish the articular surface clinically. The humeral metaphyseal fragment also enlarges and becomes misshapen. Because of apprehension and pain, the elbow undergoes disuse osteoporosis and any type of manipulative reduction is difficult. The associated fibrosis and callus makes this task further difficult.

The main reasons for avoidance of surgery upon late

presenting or established nonunion of lateral condyle are propensity to loss of elbow motion and risk of avascular necrosis of the fragment.^{4,8,9,22} Further, the established nonunions may be entirely [Table 5] asymptomatic.^{23,24} More recently, data is accumulating toward successful operative intervention in these cases either in form of osteosynthesis or corrective osteotomies.^{5,6,8,21,22,25-27} Patient’s attendants should be explained the risks and benefits of osteosynthesis especially when intervention involves an asymptomatic elbow. It is our practice to internally fix these injuries in patients who give consent because of possibility of development of future valgus deformities and neurological signs in children. An earlier fixation is preferred because it enables the physis to take part in the growth process of the distal humerus. Many of these elbows present with troublesome symptoms. The common symptomatology associated with delayed presentation is pain and stiffness, cubitus valgus, tardy ulnar nerve palsy and sometimes instability. Shimada *et al.* in their study of 16 patients with established nonunion of lateral condyle found the following presenting symptoms 5 months to 10 years after the injury- apprehension ($n = 9$), pain ($n = 7$), cubitus valgus ($n = 6$), ulnar nerve dysfunction ($n = 4$) and limitation of motion ($n = 3$).⁶ Another study of 30 patients with established nonunion lateral condylar fractures (5-57 years postinjury) reported ulnar nerve dysfunction ($n = 30$), apprehension and/or pain in elbow on carrying load ($n = 15$) and cubitus valgus ($n = 2$).⁸ In current study, the average delay was 16 weeks and pain, swelling, restriction of elbow motion were predominant.

There has been much emphasis on preservation of blood supply of rotated lateral condylar fragment during operative procedure. Flynn *et al.* emphasized this point by

advising against surgery when ununited fragment was in a poor position and would probably have required major dissection.²⁵ Bohler used transolecranon approach to avoid extensive soft tissue dissection.²⁸ Roye *et al.* recommended 'functional reduction' in which the lateral condylar fragment is placed in a position that yields maximum elbow motion.⁵ Gaur *et al.* suggested technique of making multiple incisions in the common extensor aponeurosis for aiding reduction.²⁹ Because of variable lateral condylar fragment size and displacement, the method of osteosynthesis varied. We prefer using the conventional Kocher incision for surgical procedures. Bryan and Morrey extensile approach to elbow was used in cases where condylar fragment was high riding.¹¹ We prefer using 2-3 Kirschner wires for fixation of fracture fragments. Multiple Kirschner wires offer a good fixation method as they can be passed through the physis and at multiple directions providing stability.

There are variable results in literature following operative fixation of late presenting lateral condylar fractures in children and method of result evaluation also varies considerably.^{13,19,20} Dhillon *et al.* reported on 16 pediatric patients operated after 3 weeks of injury.¹⁹ Overall elbow function was good in 5, fair in 7 and poor in 4 patients based on an indigenous clinical score devised by them. They recommended against surgery in patients presenting more than 6 weeks after injury but also observed that untreated cases always resulted in subsequent valgus deformity. Toh *et al.* used Broberg and Morrey score to grade their results in series of 20 patients presenting more than 6 months after initial injury.²⁰ Their patients were aged between 6 and 25 years. Outcome was rated as excellent in 7 and good in 13 patients. Saraf and Khare in a recent series analyzed results in 16 patients with lateral condylar humeral fractures 5-12-weeks old using criteria defined by Agarwal *et al.*^{13,14} They observed excellent to good results in 6, fair in 6 and poor results in 4 patients. Liverpool Elbow Score (LES) assesses range of movement of elbow, forearm rotation, ulnar nerve function, pain and use of affected limb in all necessary daily activities which are very essential in circumstances of developing countries. In the present series, fracture union and LES were evaluated and no correlation was found between delay in presentation with elbow function score (LES score) achieved at followup. The fracture united in all cases except one. The average LES score in our study was 8.12 (range, 6.66-9.54). Fourteen patients had scores equal or greater than 8 which correlates with satisfactory elbow function. None of the patients had scores below 6. Loss of range of motion of elbow was observed in patients but significant difference greater than 20 degrees was seen only in 2 cases (case 6 and 15). Significant loss of elbow extension was noted in 3 cases (≥ 15 degrees). These probably resulted from joint

incongruity resulting from repositioning of remodeled articular surfaces, new bone formation and fibrosis. Fish tail deformity and premature epiphyseal closure posed no functional difference as observed in other series [Figure 2].^{6,30,31} There was 1 case of infection and avascular necrosis of lateral condylar fragment and low LES.

Most of the descriptions of neglected lateral condylar fractures in literature date back to periods when diagnostic and medical facilities were not widely available especially in developing countries. With improvement of health services these late presentations are becoming rarer. Our study has limitation of a small sample size, heterogeneity, and the followup of some of the cases in our series is short. No correlation to the degree of fracture displacement could be made because of difficulty in obtaining optimal radiographs due to preoperative restriction of elbow motion. The rotated and/or mobile high riding fragments correlated poor with radiographic measurements. However, a distinction between minimal displaced and gross displaced was possible and therefore calculated [Table 2]. Almost all of our patients had yet to gain their pubertal growth spurt, obviously longer studies need to be taken to find the behavior of the lateral condylar epiphysis and alteration in function with remodeling. It is highly desirable to keep these patients under longer followup.

There is high rate of union and satisfactory elbow function in late presenting lateral condyle fractures in children following osteosynthesis. Mobilize the rotated condylar fragment on a carefully dissected soft tissue pedicle. Use a simpler implant such as Kirschner wire or screw and always bone graft the fixation. Our study showed poor correlation between patient's age, duration of late presentation, Milch types and final elbow function.

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